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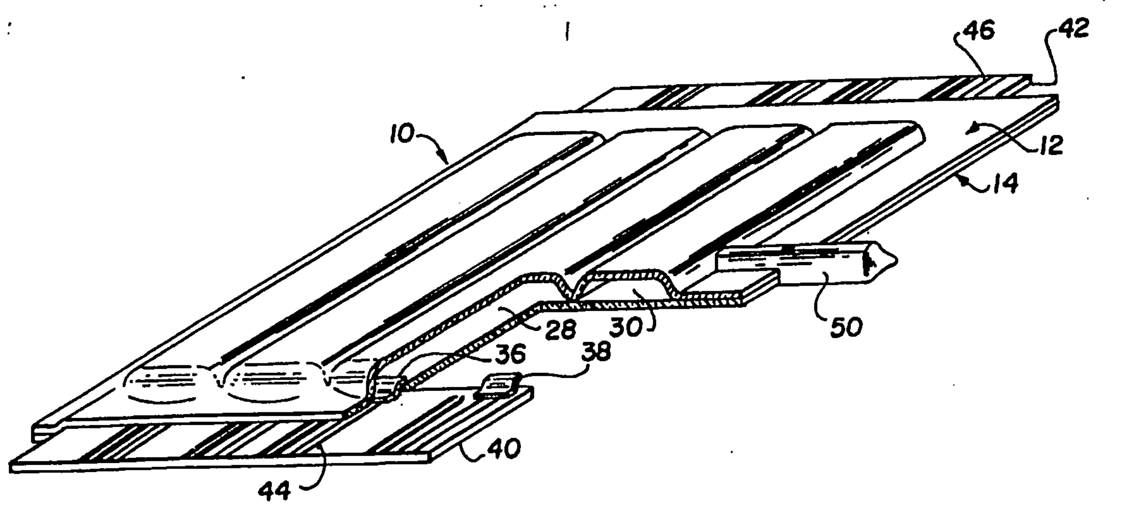

(57) Abstract

A thin configuration flat form glass envelope for use in vaccum tubes, incandescent lamps, fluorescent lamps and other electronic devices having elements which operate in a partial vacuum. In certain embodiments the envelope is comprised of a flat wall plate (14) and shaped wall plate (12) having a plurality of spaced-apart ridges (16, 18, 20) which project toward and in juxtaposition with the flat plate (14). The side walls of the ridges converge at a predetermined included angle and merge at a sharp apex that contacts the flat plate along a narrow path which produces minimal degradation of brightness uniformity across the envelope when light is transmitted through the shaped plate. Between the ridges a plurality of channels (28, 30) are formed containing an ionizable medium which is energized by electrodes to produce UV light which in turn is absorbed by a phosphor coating to emit visible light. In other embodiments the envelope is formed by two shaped plates joined together in facing relationship to form the channels.

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THIN CONFIGURATION FLAT FORM VACUUM-SEALED ENVELOPE

Background of the Invention

This is a continuation-in-part of application serial no. 07/562,251 filed August 3, 1990.

This invention relates in general to the construction and operation of glass envelopes containing internal elements and/or gases under partial vacuum, such as lamps and various electronic devices. More particularly, this invention relates to vacuum tubes, incandescent lamps, fluorescent lamps and other devices which employ glass envelopes to allow internal elements to operate in isolated atmospheres under partial vacuum conditions.

Vacuum tubes, incandescent lamps, fluorescent lamps, electronic devices and the like employ glass envelopes that enclose the internal elements in gaseous atmospheres at very low pressure or partial vacuum conditions. A fundamental problem with such a type of glass envelope is that it must withstand atmospheric pressure without breaking. Prior art designs achieve this by forming the envelopes in spherical, tubular, or combination spherical/tubular shapes which have inherent resistance to the externally applied compression forces of atmospheric pressure.

The need has been recognized for vacuum-sealed glass envelopes which have a very thin and flat configuration for use in vacuum-sealed devices of the type described. Among the devices which would benefit through the use of thin configuration flat form envelopes are electron tubes in which the elements are arrayed sequentially or in a plane. Other examples are vacuum fluorescent or incandescent filament display devices having elements which are viewed through the glass envelope. Heretofore such devices have used flat glass envelopes, but their size has been severely limited because as the span width increases the glass thickness must correspondingly increase to resist atmospheric pressure. Other examples that could benefit from flat form envelopes are lamps, such as fluorescent lamps, which heretofore have been produced in tubular form so as to withstand atmospheric pressure.

In the prior art, glass vacuum envelopes of flat configuration can be constructed sufficient to sustain atmospheric pressure by using thick glass plates, but in such case the vacuum tube becomes undesirably thick and heavy. For example, a flat fluorescent lamp of 154 mm x 112 mm planar dimensions requires a heavy glass of 18 mm thickness weighing 450 grams. A fluorescent lamp of such a design is impractical for many applications, such as LCD back lighting.

The prior art includes panel lamp designs of the type disclosed in U.S. patent no. 3,226,950 to Christy and U.S. patent no. 3,646,383 to Jones et al. As disclosed in those patents, the front and back plates of the panels are shaped with multiple embossments that match when fitted together to create a labyrinth channel. The panels are of relatively large scale with a thickness on the order of one inch or more. Wide flat bearing surfaces are formed between the channels. This creates brightness uniformity problems. In the patents the provision to alleviate the

brightness uniformity problem requires special shapes and dimensions in the walls of the embossments.

Certain prior art flat vacuum tube designs have been proposed in which separate support elements or other artifacts are inserted between the front and back glass plates. This technique is commonly used in many types of display devices. An example is United States patent 4,767,965 to Yamano, et al. In the Yamano patent flat glass plates are supported by separate spacer pieces which can be either glass pipes, glass balls, half discs or mounds of deposited frit material. Moreover, the use of the separate spacers increases the complexity and cost of fabrication, and the spacers can be interruptive or incompatible with the vacuum tube function. For example, the spacers can create non-lighted areas when used within a flat fluorescent lamp.

<u>Objects and Summary of the Invention</u>

It is a general object of the invention to provide a vacuum-sealed envelope of very thin and flat configuration for use in vacuum tubes, incandescent lamps, fluorescent lamps, electronic devices and other structures in which internal elements and/or gases are contained under partial vacuum conditions.

Another object is to provide a vacuum-sealed envelope of the type described which is in flat form for enhancing the spatial relationship of the elements and parts mounted internally within the envelope, such as in a sequential element array or in a planar array.

Another object is to provide a flat form envelope of the type described which provides enhanced visual characteristics, such as for vacuum

fluorescent or incandescent filament display devices in which elements are actually viewed through the glass envelope.

Another object is to provide a vacuum-sealed envelope of the type described which provides a more desirable overall form factor in relation to the equipment into which the envelope must fit, such as the back light for a liquid crystal display, instrument panel, aircraft lighting, surface mounted lights and the like.

The invention in summary provides a thin configuration vacuum envelope comprising, in certain embodiments, a flat wall plate spaced in parallel relation from a shaped wall plate. The shaped plate is integrally formed with a support structure comprised of spaced-apart ridges having side walls which converge together at apexes and support the opposing surface of the flat plate. The ridge apexes contact the plate at narrow, substantially line contact paths which produce minimal degradation of brightness uniformity. The cavity between the plates is hermetically sealed for confining elements of the lamp or other device and/or gases within a partial vacuum. In other embodiments, the envelope comprises a pair of shaped wall plates having projecting portions which are in contact when the plates are mounted together.

The foregoing and additional objects and features of the invention will appear from the following specification in which the several embodiments have been described in connection with the accompanying drawings.

Brief Description of the Drawings

FIG. 1 is a perspective view, partially cut away, of a flat fluorescent lamp illustrating one preferred embodiment of the invention;

FIG. 2 is a cross-sectional view, to an enlarged scale, of the lamp of FIG. 1;

FIG. 3 is an enlarged cross-sectional view of portions of the channel segments of the lamp of FIG. 1;

FIG. 4 is a schematic view of another embodiment providing a flat lamp with a parallel channel pattern;

FIG. 5 is a schematic view of another embodiment providing a flat lamp with a serpentine channel pattern;

FIG. 6 is a schematic view of another embodiment providing a flat lamp having a plurality of serpentine channels which are clustered together.

FIG. 7 is a perspective view, partially cut away, of a flat fluorescent lamp illustrating one preferred embodiment of the invention;

FIG. 8 is a fragmentary cross-sectional view, to an enlarged scale, of a portion of the lamp of FIG. 7;

Detailed Description of the Invention

Referring to the drawings, FIGS. 1, 2 and 3 illustrate one preferred embodiment of the invention providing a flat form fluorescent lamp 10. While the invention will be described in relation to fluorescent lamp applications, it is understood that the invention encompasses other applications, such as vacuum tubes, incandescent lamps, electronic devices and various other similar devices of the type incorporating glass

envelopes enclosing a partial vacuum in which the internal elements operate and/or in which gases are contained.

Fluorescent lamp 10 is comprised of a shaped wall plate 12 mounted over a flat wall plate 14 to provide a thin, flat form envelope for confining a partial vacuum or gaseous atmosphere. The wall plates are comprised of a suitable transparent or translucent vitreous material such as clear glass.

In a typical application, the flat plate is the back side of the lamp while the shaped plate is the front side through which light is transmitted. In other applications for the lamp, the flat plate could be the front side for transmitting light. The non-light-transmitting back side could be fabricated from an electrically conductive substrate, preferably metal, covered with a glass layer. The substrate would be a suitable metal such as stainless steel with thermal expansion properties compatible with the glass of the layer. The side of the back plate with the glass layer would face the front plate and be sealed about the outer periphery. Depending upon the requirements of a particular application, the metal substrate with its glass layer could define either the shaped plate or the flat plate of the envelope.

A support structure is integrally formed on the inside of the shaped plate and comprises a plurality of spaced-apart ridges 16, 18, 20 which project into juxtaposition with the opposing inner surface 22 of the flat plate. The ridges serve as spacers which support the plates in parallel, spaced-apart relationship to form elongate cavities or channels 24-30 between the ridges. As required, the ridges can be sealed to the flat plate by means of a glass frit for sealing between the adjacent channels.

As best shown in FIG. 3, the plate ridges 16-20 are formed with a cross section in which a pair of side walls 32, 34 converge at a predetermined included angle β. The side walls of each ridge merge at a sharp apex 35 that contacts inner surface 22 of the flat plate along a very narrow contact path, which can be considered substantially a line contact. The side wall angle β preferably is in the range of 40° to 90°, and in the illustrated embodiment this angle is 90°.

The configuration and size of the wall plates in the invention provides implosion resistance against atmospheric pressure when the channels are evacuated. Depending upon the particular application, the plate wall thickness T_p is principally a function of the span width W_r between the ridges. With a relatively large span width W_r the plate thickness T_p is correspondingly greater so that the plates have sufficient structural strength for implosion resistance. The invention also provides a specific cross-sectional dimensional aspect ratio W_r:H_c in the range of 5:1 to 10:1. The dimensional aspect ratio H_c:T_p is also in the range 1.5:1 to 3:1. In a typical application for a fluorescent lamp where the channels are sized so that W_r = 0.400" and H_c = 0.060" then the wall plate thickness T_p is sized in the range of 0.02" to 0.045". This produces an overall lamp thickness T_1 in the range of 0.100" to 0.150".

The preferred method of fabricating the shaped wall plate is by use of a suitable mold, not shown, having surfaces which correspond to the desired shape. The mold is heated, and then pre-heated glass sheets are pressed between the mold surfaces so that the plastic glass flows into conformance with the mold curvature. The flat and shaped wall plates are then assembled together so that the ridges contact the opposing flat plate. A small spacing, not shown, is initially provided along the peripheral rims of the plates to facilitate forming a vacuum tight seal. A suitable glass frit, not shown, is glazed in the peripheral spacing to seal

the edges of the envelope. Discharge electrodes 36, 38 are then mounted on a pair of electrode substrates 40 and 42 which are inserted at opposite ends of the cavities before the plates are sealed. Inleads 44, 46 are printed or otherwise adhered to the substrates for connecting the electrodes with a suitable AC drive control circuit, not shown.

Either or both of the inner surfaces 22 and 48 of the respective glass plates 12 and 14 are coated with a suitable activated powdered phosphor such as Magnesium Tungstate or calcium Fluorochlorophosphate:Antimony:Manganese. The cavities 24-30 are exhausted to a partial vacuum by means of suitable exhaust tubes (one is shown at 50) or other means. An ionizable medium comprising a mixture of inert gas such as Argon and a small percentage of Mercury gas is then charged into the cavities. Gas pressure within the gas cavities preferably is within the range of three to thirty torr.

During operation free electrons are accelerated by the electric field applied between the electrodes at opposite ends of the channels. When these electrons collide with neutral atoms/molecules the latter are ionized when sufficient voltage is applied. This creates ion-electron pairs. The ions are swept to the electrode surfaces and can provide secondary electrons when colliding with the electrode surfaces. These secondary electrons are swept toward the other electrode creating additional ion-electrons. At sufficient voltage an avalanche or arc occurs causing the gas to be highly ionized creating many ion-electron pairs as well as many excited atoms/molecules. When these excited atoms/molecules decay to their ground state they give off photons of energy. The partial pressure of Mercury is particularly rich in radiating ultraviolet photons. The phosphor coating absorbs the ultraviolet radiation and re-radiates at wave lengths visible to the human eye.

As required by the area size requirements of a particular application, the length and width dimensions of the plates can be scaled up by repeating or extending the various matrix patterns for the projecting portion described in the foregoing embodiments.

FIG. 4 illustrates an embodiment providing a flat lamp 51 in which the channels are arranged in parallel paths. The shaped wall plate 52 is formed with four spaced-apart ridges 54-60. When the ridges are mounted in juxtaposition with the flat plate, five elongate parallel channels 62 are defined for containing the gaseous atmosphere under partial vacuum. Discharge electrodes 64, 66 are mounted in the opposite ends of each channel. Inleads 68, 70 connect the electrodes into a drive control circuit 72 which in turn receives power from AC source 74. Control circuit 72 synchronously drives all five channels by simultaneously applying continuously variable voltages to the discharge electrodes. Any suitable synchronous drive control circuit design can be used for this purpose. When the channels are synchronously driven in this manner, the voltage differentials between channels are not high, thereby obviating the requirement to create tight interchannel sealing along the ridges. There is little channel-to-channel breakdown across the ridges even where the channel barriers are narrow and unsealed.

FIG. 5 illustrates another embodiment providing a flat lamp 76 having multiple channels in a serpentine path for the flow of current through the ionized gases. In the illustrated embodiment four channels 78 are defined by three spaced-apart ridges 80-84 formed in a shaped plate 86. Each ridge has an end 88 which terminates short of the ends of the channels so that the ends of the adjacent channels are in open communication. The terminated ends of the ridges alternate to define the serpentine path. In this embodiment the lines of contact between the ridges and the opposing flat plate are sealed to electrically isolate

adjacent channels. The serpentine pattern creates relatively higher interchannel voltage potentials which would otherwise create channel-to-channel breakdown across unsealed channel barriers. Discharge electrodes 90, 92 are mounted at the closed ends of the channels on either side of the envelope. Inleads 94, 96 connect the electrodes with a drive control circuit 98 which in turn is coupled with AC power source 100. The size of the lamp envelope can be scaled up by increasing the number of channels in the serpentine pattern, as required by the particular application.

FIG. 6 illustrates an embodiment providing a flat lamp 102 having a plurality of separate serpentine channels arranged in multiple clusters. In the illustrated embodiment three clusters 104-108 are provided. Each cluster is formed by a pattern of three ridges, for example ridges 110-114 for cluster 104. Alternate ends of the ridges are terminated short to provide open communication between the ends of each channel pair in the manner described for the embodiment of FIG. 5. Pairs of electrodes 116, 118 are provided for each cluster, and the electrodes are mounted in the closed ends of the channels at either side of the respective clusters. An AC power source 120 and drive control circuit 122 are connected to the electrodes through inleads 124, 126. Drive circuit 122 can either independently drive the clusters, or the clusters could be driven in parallel, as required by the particular application.

The previously described parallel, serpentine or cluster serpentine configurations can also be fabricated by the two shaped plate construction described below. The line contact formed by opposing ridges can be either glass frit sealed for prevention of voltage breakdown, or not sealed if the voltage potential does not require sealing.

FIGS. 7 and 8 show another embodiment providing a fluorescent lamp 130 with shaped wall plates which are in facing relationship. Lamp 130 is comprised of generally planar top glass plate 132 and bottom glass plate 134 which are mounted together and sealed about their peripheral edges 136 and 138. In the illustrated embodiment the top and bottom plates are each formed with support structures which comprise a matrix of projecting portions 140 and 142. The support structures are generally arch-shaped in cross-section and form linear parallel ridges 144 and 146. The linear portions of the plates which form the walls of the ridges curve toward each other (see FIG. 8) where they are in bearing contact along the apexes of the ridges. The curved walls create arch structures which provide high column strength against compression forces.

The top and bottom plates are mounted so that their corresponding ridges are in contact. The lines of contact along the matching ridges provide the linear bearing areas 148 for the compression forces. The ridges hold the flat portions of the top and bottom plates spaced apart at a predetermined gap distance so that elongate, parallel cavities 150, 152 are formed between the two plates. All of the cavities are internally open to each other so that the cavities combine to form one sealed envelope for confining the gaseous atmosphere under partial vacuum. The length of the gas cavities, and the number of cavities, is dependent upon the required size of the lamp. As an example, for a lamp surface area of 77.42 cm^2 the thickness of each glass plate is 0.7 mm, the height of each gas cavity is 1.4 mm, and the spacing between the ridges is 9.5 mm. Each projecting portion extends 0.7 mm from the inner surface of the respective plate, and the radius of curvature of each ridge wall is 1.5 mm.

The preferred method of fabricating the top and bottom plates is by use of a suitable mold having surfaces which correspond to the desired shape

of the plates. The mold is heated, and then pre-heated glass sheets are pressed between the mold surfaces so that the glass flows into conformance with the mold curvature. The top and bottom plates are then assembled together so that the ridges contact each other. A small spacing, not shown, is provided along the periphery of the plates to facilitate forming a vacuum tight seal. A suitable glass frit, not shown, is glazed in the peripheral spacing to seal the edges of the envelope. Suitable electrodes 154 mounted on a pair of electrode substrates 155 and 156 are inserted at opposite ends of the cavities before the plates are sealed. In addition, the inner surfaces 157 of the glass plates are coated with a suitable activated powdered phosphor such as Magnesium Tungstate or calcium Fluorochlorophosphate:Antimony: Manganese. The cavities 150, 152 are exhausted to a partial vacuum by means of an exhaust tube 159. A mixture of inert gas such as Argon and a small percentage of Mercury gas is then charged into the cavities. Gas pressure within the gas cavities preferably is within the range of three to thirty torr. A suitable power source, not shown, drives the electrodes with AC voltage through an external circuit which connects through conductors 158, 160 formed on the electrode substrates at opposite ends of the lamp.

As required by the area size requirements of a particular application, the length and width dimensions of the plates can be scaled up by repeating or extending the various matrix patterns for the projecting portion described in the foregoing embodiments. This can be achieved without increasing the glass thickness because with the invention an enlargement of the matrix pattern does not affect the column strength of the individual modules or cells of the matrix.

The invention also contemplates that the projecting portions of the wall plate support structure can be shaped in other configurations consistent

with the particular material and wall thickness of the glass. The arch configuration of the projecting portions could also be varied in accordance with particular requirements provided that adequate column strength results. The walls of the projecting portions could also be substantially flat, and an example of this would be ridges of truncated cross-sectional shape.

While the foregoing embodiments are at present considered to be preferred it is understood that numerous variations and modifications may be made therein by those skilled in the art, and it is intended to cover in the appended claims all such variations and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. A thin configuration flat form envelope for confining a partial vacuum or gaseous atmosphere for use in an electronic lamp, bulb, tube or the like, said envelope comprising the combination of a flat wall plate, a shaped wall plate, at least one of said flat or shaped wall plates being comprised of transparent vitreous material, a support structure integrally formed on one side of the shaped plate, said support structure comprising at least one ridge which projects from said one side of the shaped plate toward and in juxtaposition with the opposing surface of the flat plate, said ridges supporting the plates in a parallel, spaced-apart relationship which defines a cavity therebetween, said ridge having a pair of side walls which converge at a predetermined included angle and merge at a sharp apex that contacts the opposing surface of the flat plate along a contact path, and means for creating an hermetical seal between the outer perimeters of the flat and shaped wall plates whereby the cavity is hermetically sealed for confining the partial vacuum or gaseous atmosphere.

2. A flat form envelope as in claim 1 in which the included angle between each pair of side walls is in the range of 40° to 90°, and said contact path is substantially a line contact which produces minimal degradation of brightness uniformity across the envelope when light is transmitting through the shaped plate.

3. A flat form envelope as in claim 1 in which a plurality of the ridges are formed in parallel relationship, adjacent pairs of said ridges define a plurality of channels, an ionizable medium confined in the channels, and including electrode means for producing current flow in a path through the gasses along the length of each channel.

4. A flat form envelope as in claim 3 in which the ridges form a plurality of said channels disposed in side-by-side relationship, and said electrode means comprises means providing electrodes in opposite ends of each channel for creating independent current paths through the gasses along each channel.

5. A flat form envelope as in claim 4 which includes circuit means for driving the electrodes in each channel synchronously with the electrodes in the channels adjacent thereto.

6. A flat form envelope as in claim 4 in which the channels are oriented in pairs, and including circuit means for driving the electrodes synchronously in each pair of channels.

7. A flat form envelope as in claim 1 in which said ridge defines at least two channels which are in open communication at a common end to define a serpentine path for said current flow.

8. A flat form envelope as in claim 7 in which said envelope confines a plurality of ridges which define two or more of said serpentine paths which are mutually independent.

9. A flat form envelope as in claims 1, 7 or 8 which includes means for sealing the ridges gas-tight with said opposing surface of the flat plate along the contact paths between adjacent channels to provide inter-channel sealing for preventing short circuits between the adjacent channels.

10. A flat form envelope as in claim 1 in which the support structure has a cross-sectional dimensional aspect ratio W_r:H_c in the range of 5:1 to 10:1 where

W_r is the width of the channel measured between the apexes of adjacent ridges, and

H_c is the height of the cavity measured between the opposing surfaces of the plates.

11. A flat form envelope as in claims 1 or 11 in which the support structure has a cross-sectional dimensional aspect ratio h:t in the range of 1.5:1 to 3:1 where

H_c is the height of the cavity measured between the opposing surfaces of the plates, and

T_p is the wall thickness of the flat plate

12. A flat formed envelope for confining a partial vacuum in an hermetically sealed lamp, bulb, tube or other enclosure of glass or like material, said envelope comprising the combination of a pair of wall plates, means for mounting the wall plates in generally parallel relationship with opposing inner surfaces of the plates spaced apart at a predetermined gap distance to define a cavity for confining the vacuum, each of said wall plates including a support structure comprising a matrix of projecting portions which extend outwardly from the inner surface thereof into contact with bearing areas on opposing portions of the other wall plate, said projecting portions having predetermined cross-sectional shapes providing column strength sufficient to hold the wall plates at said predetermined gap distance against the compression forces resulting from atmospheric pressure acting against the partial vacuum within the cavity.

13. A flat form envelope as in claim 12 in which the projecting portions comprise a plurality of ridges which extend in parallel relationship across the respective plate.

14. A flat form envelope as in claim 12 in which the projection portions are arch-shaped in cross-section.

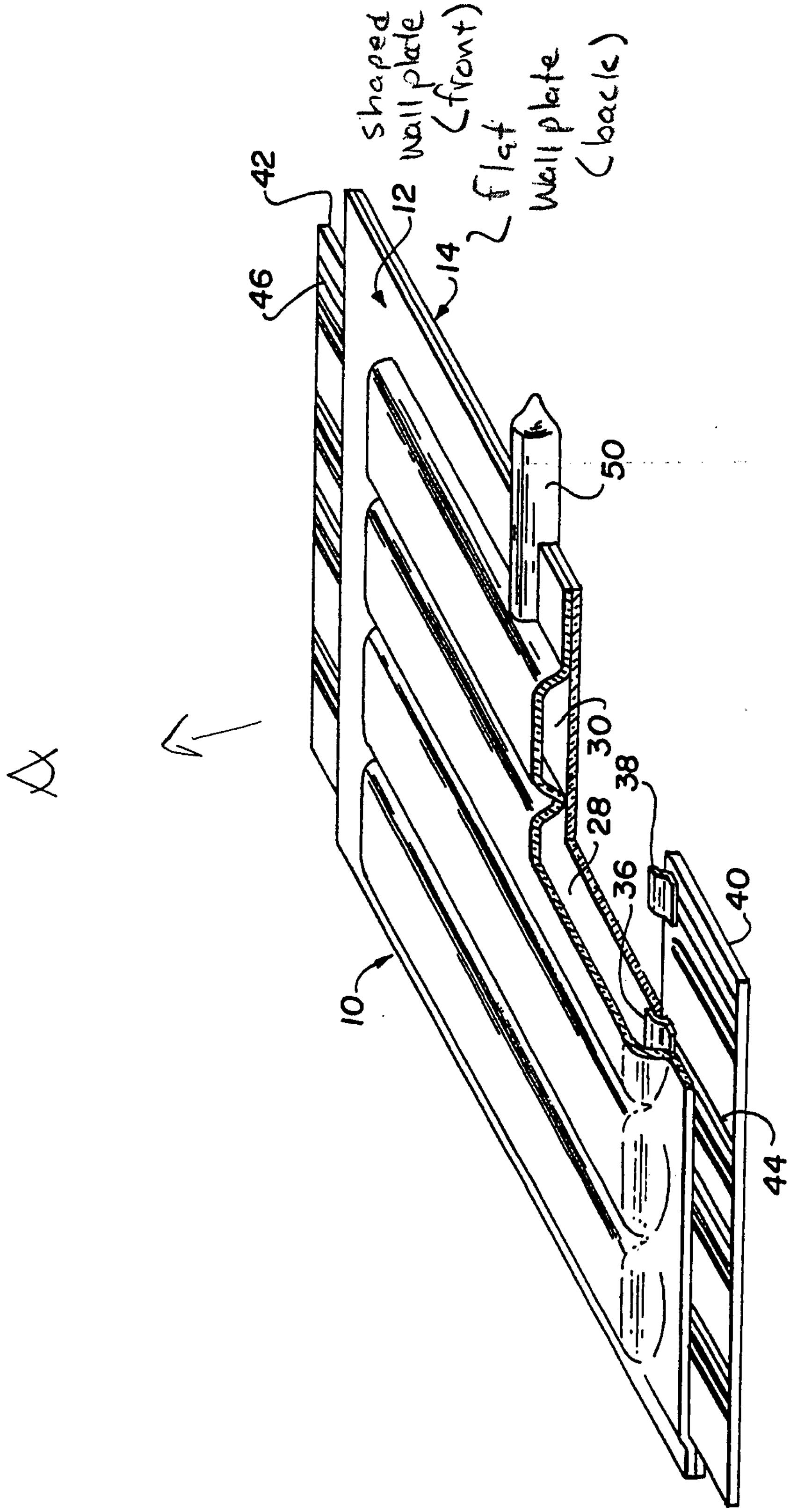
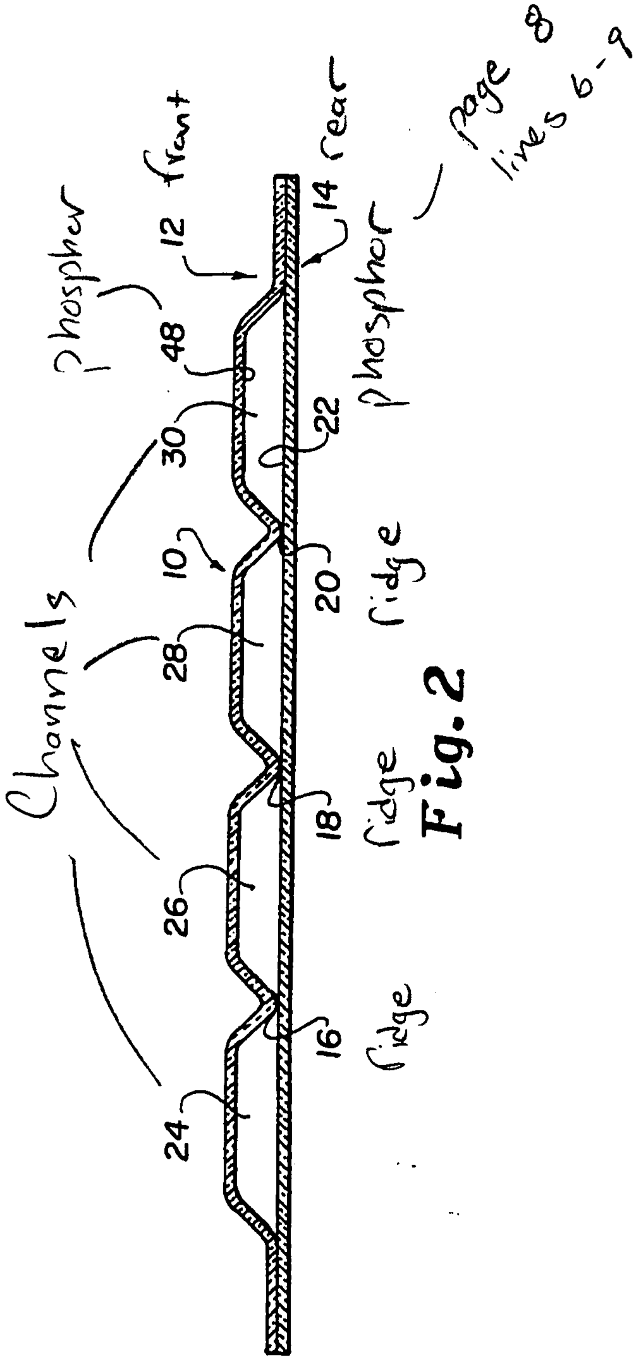

shaped wall plate (front)
flat wall plate (back)
42
46
12
14
50
30
28
38
36
40
10
44

Fig.1


Channels
Phosphor
12 front
14 rear
phosphor
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48
30
22
10
20
ridge
28
18
ridge
26
16
ridge
24

Fig. 2

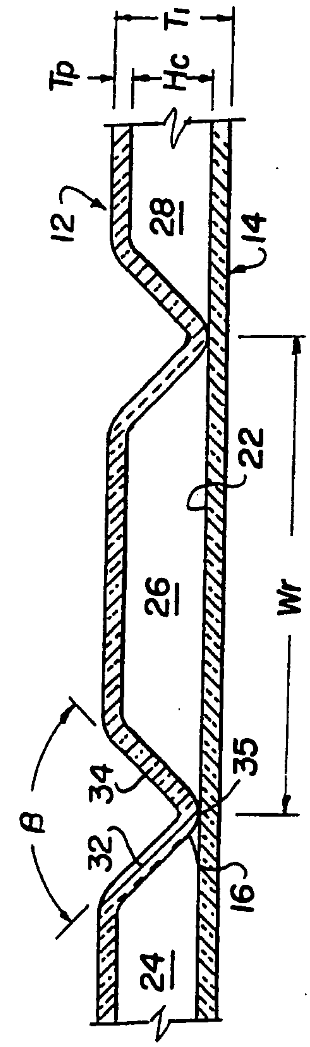
Tp
Hc
Tr
12
28
14
22
26
Wr
35
34
B
32
16
24

Fig. 3

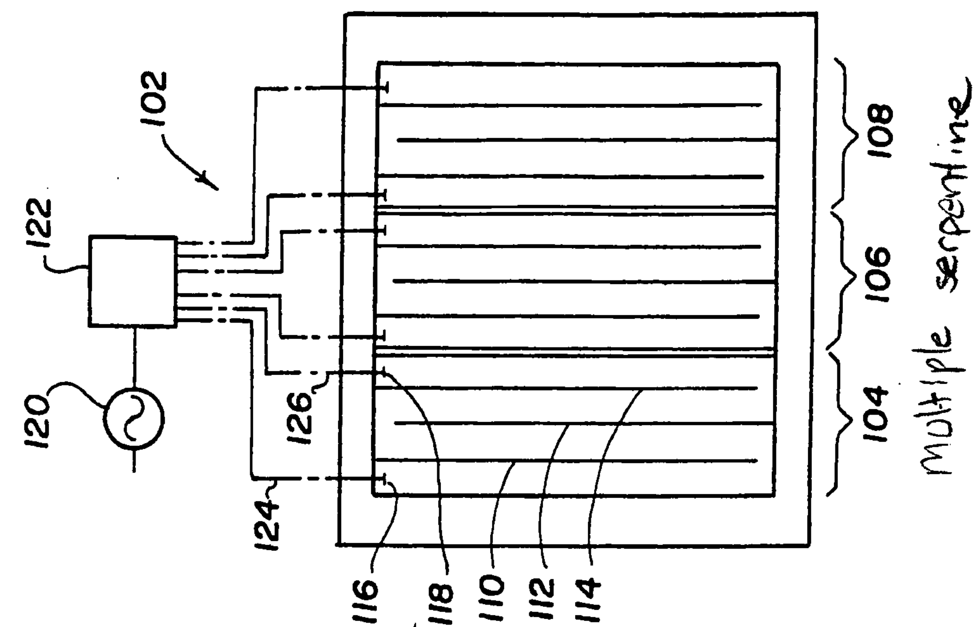

Fig.6

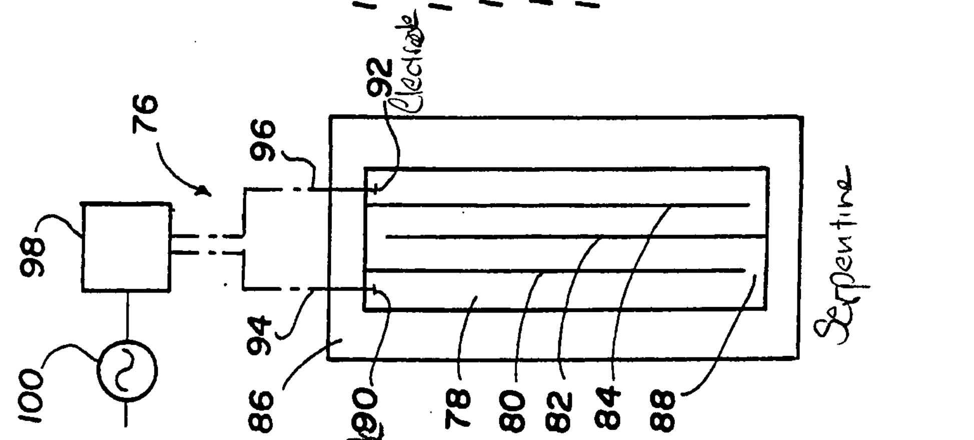

Fig.5

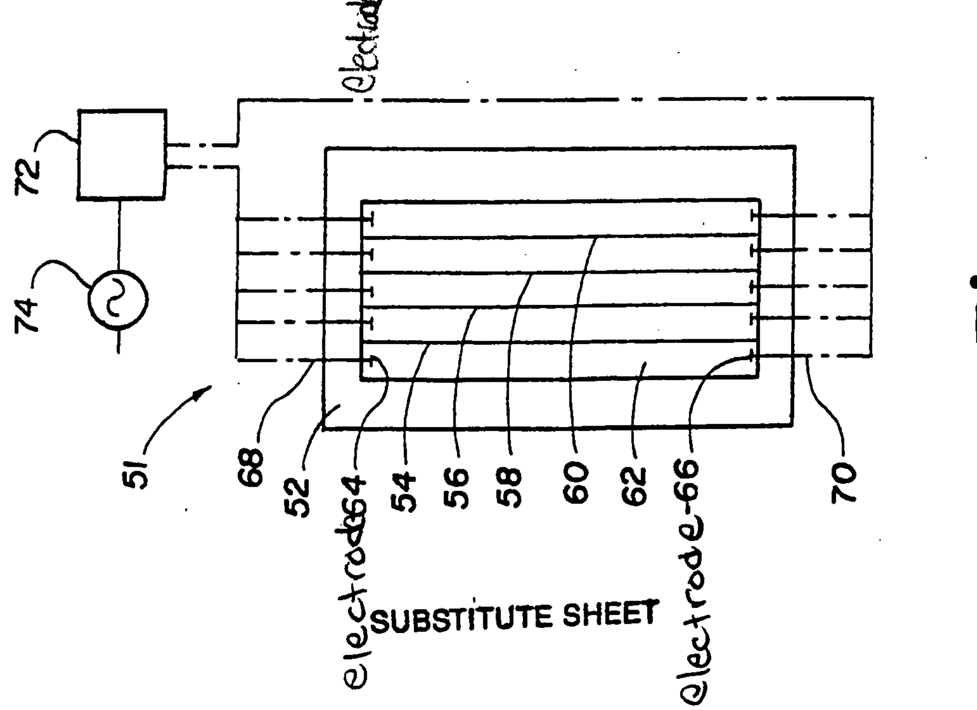

Fig.4

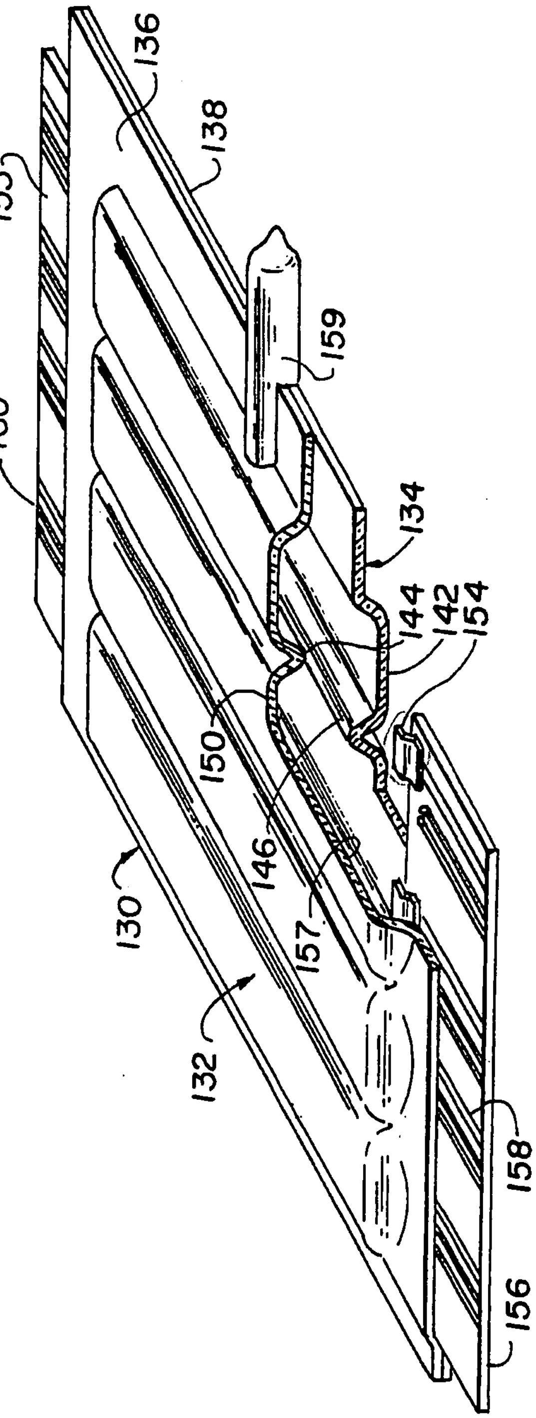

Fig.7

both plates have channels Which are parallel

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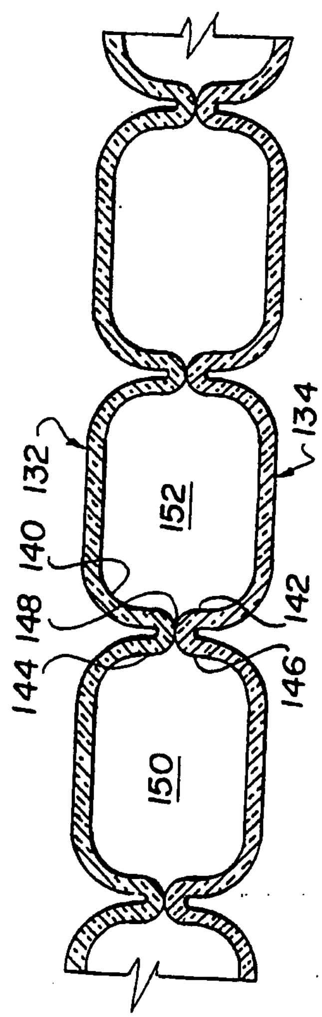

Fig.8

SUBSTITUTE SHEET

INTERNATIONAL SEARCH REPORT

International Application No. PCT/US91/04997

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC(5): H01J 61/30; H01K 1/28

US.CL: 313/493

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
US	313/493, 609,610,611, 612,634 220/2.1R

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category *	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
X	US,A, 2,102,049 (Warren) 14 December 1937 see entire document	1,3,7,9,12,13
X	US,A, 3,646,383 (Jones) 29 February 1972 see the entire document	12-13
A	EP,A, 0077,077 (Schipp) 20 April 1983 See the abstract and drawing.	1-14

* Special categories of cited documents: [10]

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"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
16 September 1991	09 DEC 1991
International Searching Authority	**Signature of Authorized Officer**
ISA/US	Nimeshkumar D. Patel

Form PCT/ISA/210 (second sheet) (Rev.11-87)